CLAIMS

1. A microphone assembly providing substantial response to an incident sound wave over a range of angle of arrival theta and over at least a frequency range from a lower first frequency to an upper second frequency, said first and second frequencies corresponding respectively to a first and a second wavelength, said assembly comprising:

at least two microphones having a microphone directionality, each of said at least two microphones generating an electrical microphone signal corresponding to said incident sound wave;

circuitry for generating at least one pattern signal from the electrical microphone signals, one of said at least one pattern signal exhibiting a pickup pattern which varies according to said angle of arrival theta substantially uniformly over said frequency range, said pickup pattern approximately equal to the microphone directionality modified by a factor of 1 - B + B*cos(theta); and

at least one filter for attenuating frequency components of said at least one pattern signal which are lower than said lower first frequency.

2. The microphone assembly according to claim 1, wherein said at least two microphones are spaced apart by at least one spacing distance which is not less than 1/5 of said second wavelength multiplied by said constant B.

3. The microphone assembly according to claim 2 wherein said at least one spacing distance is not less than 1/3 nor greater than 4/5 of said second wavelength multiplied by said constant B.

4. The microphone assembly according to claim 1 wherein said at least one filter is a high-pass filter of at least second order.

5. The microphone assembly according to claim 4 wherein said filter shapes the frequency response above said second frequency.

6. A microphone assembly according to claim 1 wherein the microphone directionality of said at least two microphones is substantially omnidirectional.

7. A plurality of microphone assemblies according to claim 1 acoustically coupled to a common volume of space and further including a microphone assembly selector, said selector applying variable gain or attenuation to outputs of said microphone assemblies as a function of acoustical inputs to said assemblies.

8. A microphone assembly according to claim 1, further comprising an additional output, said additional output comprised solely of any one of said electrical microphone signals.

9. A microphone assembly providing substantial response to an incident sound wave over a range of angle of arrival theta and over at least a frequency range from a lower first frequency to an upper second frequency, said first and second frequencies corresponding

respectively to a first and a second wavelength, said assembly comprising:

at least two microphones having a microphone directionality which is substantially omnidirectional, each of said at least two microphones generating an electrical microphone signal corresponding to said incident sound wave;

said at least two microphones spaced apart by at least one spacing distance and positioned on a microphone side of an acoustical barrier, said barrier of a size having at least one dimension which is greater than said second wavelength and providing substantial attenuation of acoustical coupling to said microphone side from an opposite side of said barrier over at least said frequency range, each of said at least two microphones having a diaphragm acoustically coupled through at least one acoustical opening to said opposite side of said barrier, each of said at least one acoustical opening constructed so as to prevent substantial acoustical coupling from said microphone side of said barrier directly to said diaphragm;

circuitry for generating at least one pattern signal from the microphone signals, one of said at least one pattern signal exhibiting a pickup pattern which varies according to said angle theta substantially uniformly over said frequency range, said pickup pattern approximately equal to 1 - B + B*cos(theta) within a volume of space acoustically coupled to two of said diaphragms.

10. The microphone assembly according to claim 9 further comprising at least one filter for attenuating frequency components of said at least one pattern signal which are lower than said lower first frequency.

11. The microphone assembly according to claim 9 wherein said diaphragms are positioned parallel to said barrier.

12. The microphone assembly according to claim 9 wherein said at least one opening acoustically couples to said opposite side of said acoustical barrier through acoustically semi-transparent material.

13. The microphone assembly according to claim 9, wherein said at least one spacing distance is not less than 1/5 of said second wavelength multiplied by said constant B.

14. The microphone assembly according to claim 13 wherein said at least one spacing distance is not less than 1/3 nor greater than 4/5 of said second wavelength multiplied by said constant B.

15. The microphone assembly according to claim 10 wherein said filter is a high-pass filter of at least second order.

16. The microphone assembly according to claim 15 wherein said filter shapes the frequency response above said first frequency.

17. The microphone assembly according to claim 9 wherein each of said at least two microphones exhibits a substantially flat frequency response over a range of frequencies from a respective lower cutoff frequency to a respective upper cutoff frequency, and wherein each of said lower cutoff frequencies is lower than said first frequency and

each of said upper cutoff frequencies is higher than said second frequency.

18. A microphone assembly according to claim 17 wherein a ratio of said first frequency to each of said lower cutoff frequencies is greater than 5.

19. A microphone assembly according to claim 17 wherein a ratio of said first frequency to a difference between each of said lower cutoff frequencies is greater than 5.

20. A microphone assembly according to claim 17 wherein said circuitry includes at least two roll-off filters for attenuating said at least two microphone signals at frequencies below at least one roll-off corner frequency, and responsively producing at least two rolled-off signals, said at least one roll-off corner frequency lying above each of said lower cutoff frequencies of said microphones.

21. A microphone assembly according to claim 20 wherein said circuitry effectively produces at least one difference of said at least two rolled-off signals.

22. A microphone assembly according to claim 20 wherein said circuitry includes at least one delay for electrically delaying at least one of said at least two rolled-off signals and responsively producing at least one delayed signal.

23. A microphone assembly according to claim 22 wherein said circuitry effectively produces a difference of said at least one delayed signal and at least one of said at least two rolled-off signals.

24. A microphone assembly according to claim 22 wherein said at least one delay includes an all-pass filter.

25. A microphone assembly according to claim 22 wherein said at least one delay includes a low-pass filter.

26. A microphone assembly according to claim 21 wherein at least one gain applied to at least one of said at least two rolled-off signals in said circuitry is adjustable.

27. A microphone assembly according to claim 23 wherein at least one gain applied to at least one of said at least one delayed signal and at least one of said at least two rolled-off signals in said circuitry is adjustable.

28. A plurality of microphone assemblies according to claim 9 acoustically coupled to a common volume of space and further including a microphone assembly selector, said selector applying at least one of variable gain and attenuation to outputs of said microphone assemblies as a function of acoustical inputs to said assemblies.

29. The microphone assembly according to claim 9 further comprising an additional output, said additional output comprised solely of any one of said microphone signals.

30. The microphone assembly according to claim 17 further comprising an additional output, said additional output comprised of any one of said microphone signals and exhibiting substantial response at frequencies substantially lower than said first frequency.

31. The microphone assembly according to claim 29 wherein said at least one pattern signal is developed relative to a ground, and said additional output is developed relative to a local ground, said local ground connected to said ground by a ground resistance, said ground resistance exhibiting a resistance of greater than 1/50 of an expected load resistance, and wherein said additional output is developed with an output impedance, said output impedance having a value of greater than 5 times said expected load resistance.

32. The microphone assembly according to claim 30 wherein said at least one pattern signal is developed relative to a ground, and said additional output is developed relative to a local ground, said local ground connected to said ground by a ground resistance, said ground resistance exhibiting a resistance of greater than 1/50 of an expected load resistance, and wherein said additional output is developed with an output impedance, said output impedance having a value of greater than 5 times said expected load resistance.

33. A microphone assembly providing substantial response to an incident sound wave over a range of angle of arrival theta and over at least a frequency range from a lower first frequency to an upper second frequency, said first and second frequencies respectively corresponding to a first and a second wavelength, said assembly comprising:

first, second and third microphones, each having a microphone directionality, said first, second and third microphones generating, respectively, first, second and third electrical microphone signals corresponding to said incident sound wave;

said first and second microphones spaced apart by a first spacing distance;

said first and third microphones spaced apart by a second spacing distance;

first circuitry for generating a first pattern signal from said first electrical microphone signal and said second electrical microphone signal, said first pattern signal exhibiting a pickup pattern which varies according to said angle of arrival theta substantially uniformly over said frequency range, said first pickup pattern approximately equal to said microphone directionality modified by a factor of 1 - B + B*cos(theta);

second circuitry for generating a second pattern signal from said first electrical microphone signal and said third electrical microphone signal, said second pattern signal exhibiting a pickup pattern which varies according to said angle of arrival theta and an offset angle phi substantially uniformly over said frequency range, said second pickup pattern approximately equal to said microphone directionality modified by a factor of 1 - C + C*cos(theta + phi);

at least one filter for attenuating frequency components of said first and second pattern signals which are lower than said first frequency.

34. The microphone assembly according to claim 33 wherein said first spacing distance is not less than 1/5 of said second wavelength multiplied by said constant B and said second spacing distance is not less than 1/5 of said second wavelength multiplied by said constant C.

35. The microphone assembly according to claim 33 wherein said at least one filter is a high-pass filter of at least second order.

36. The microphone assembly according to claim 33 wherein said microphone directionality of said first, second, and third microphones is substantially omnidirectional.

37. The microphone assembly according to claim 33 further including a pattern selector, said pattern selector applying at least one of variable gain and attenuation to outputs of said first and second circuitry as a function of acoustical input to said assembly.

38. The microphone assembly according to claim 33 further comprising an additional output, said additional output comprised solely of any one of said first, second, and third microphone signals.

39. A microphone assembly providing substantial response to an incident sound wave over a range of angle of arrival theta and over at least a frequency range from a lower first frequency to an upper

second frequency, said first and second frequencies respectively corresponding to a first and a second wavelength, said assembly comprising:

first, second and third microphones, each having a microphone directionality which is substantially omnidirectional, each of said first, second and third microphones generating respectively, first, second and third electrical microphone signals corresponding to said incident sound wave;

said first and second microphones having first and second diaphragms, respectively, said first and second microphones spaced apart by a first spacing distance and positioned on a microphone side of an acoustical barrier, said barrier of a size having at least one dimension which is greater than said second wavelength and providing substantial attenuation of acoustical coupling to said microphone side from an opposite side of said barrier over at least said frequency range, said first and second diaphragms acoustically coupled through at least one acoustical opening to said opposite side of said barrier, said at least one acoustical opening constructed so as to prevent substantial acoustical coupling from said microphone side of said barrier directly to said first and second diaphragms;

said third microphone having a third diaphragm, said first and third microphones spaced apart by a second spacing distance and positioned on said microphone side of said barrier, said third diaphragm acoustically coupled through at least one acoustical opening to said opposite side of said barrier, said at least one acoustical opening constructed so as to prevent substantial acoustical coupling from said microphone side of said barrier to said third diaphragm;

first pattern generating circuitry for generating a first pattern signal from said first electrical microphone signal and said second electrical microphone signal, said first pattern signal exhibiting a pickup pattern which varies according to said angle of arrival theta substantially uniformly over said frequency range, said first pickup pattern approximately equal to 1 - B + B*cos(theta) within a volume of space acoustically coupled to said first and second diaphragms.

second pattern generating circuitry for generating a second pattern signal from said first electrical microphone signal and said third microphone signal, said second pattern signal exhibiting a pickup pattern which varies according to said angle arrival theta and an offset angle phi substantially uniformly over said frequency range, said second pickup pattern approximately equal to 1 - C + C*cos(theta + phi) within a volume of space acoustically coupled to said first and third diaphragms.

40. The microphone assembly according to claim 39 and further including at least one filter for attenuating frequency components of said first and second pattern signals which are lower than said first frequency.

41. The microphone assembly according to claim 39 wherein said first, second and third diaphragms are positioned parallel to said barrier.

42. The microphone combination assembly according to claim 39 wherein said at least one opening acoustically couples to said opposite

side of said acoustical barrier through acoustically semi-transparent material.

43. The microphone assembly according to claim 39, wherein said first spacing distance is not less than 1/5 of said second wavelength multiplied by said constant B and said second spacing distance is not less than 1/5 of said second wavelength multiplied by said constant C.

44. The microphone assembly according to claim 43 wherein said first spacing distance is not less than 1/3 nor greater than 4/5 of said second wavelength multiplied by said constant B and said second spacing distance is not less than 1/3 nor greater than 4/5 of said second wavelength multiplied by said constant C.

45. The microphone assembly according to claim 40 wherein said at least one filter is a high-pass filter of at least second order.

46. The microphone assembly according to claim 45 wherein said at least one filter shapes a frequency response above said first frequency.

47. The microphone assembly according to claim 39 wherein each of said first, second, and third microphones exhibits a substantially flat frequency response over a range of frequencies from a respective lower cutoff frequency to a respective upper cutoff frequency, and wherein each of said lower cutoff frequencies is lower than said first frequency and each of said upper cutoff frequencies is higher than said second frequency.

48. The microphone assembly according to claim 47 wherein a ratio of said first frequency to each of said lower cutoff frequencies is greater than 5.

49. The microphone assembly according to claim 47 wherein a ratio of said first frequency to the difference between any two of said lower cutoff frequencies is greater than 5.

50. The microphone assembly according to claim 47 wherein said first and second pattern generating circuitry includes first, second, and third roll-off filters for attenuating said first, second, and third microphone signals at frequencies below a roll-off corner frequency, and responsively producing first, second, and third rolled-off signals, said roll-off corner frequency lying above each of said lower cutoff frequencies.

51. The microphone assembly according to claim 50 wherein said first pattern generating circuitry effectively produces a difference of said first and second rolled-off signals and said second pattern generating circuitry effectively produces a difference of said first and third rolled-off signals.

52. The microphone assembly according to claim 50 wherein said first and second pattern generating circuitry includes a delay for electrically delaying said first rolled-off signal and responsively producing a delayed signal.

53. The microphone assembly according to claim 52 wherein said first pattern generating circuitry effectively produces the difference of said delayed signal and said second rolled-off signal, and said second pattern generating circuitry effectively produces a difference of said delayed signal and said third rolled-off signal .

54. The microphone assembly according to claim 52 wherein said delay includes an all-pass filter.

55. The microphone assembly according to claim 52 wherein said delay includes a low-pass filter.

56. The microphone assembly according to claim 51 wherein gain applied to at least one of said first and second rolled-off signals in said first circuitry is adjustable and gain applied to at least one of said first and third rolled-off signals in said second circuitry is adjustable.

57. The microphone assembly according to claim 53 wherein gain applied to at least one of said delayed signal and said second rolled-off signal in said first circuitry is adjustable and gain applied to at least one of said delayed signal and said third rolled-off signal in said second circuitry is adjustable.

58. The microphone assembly according to claim 39 further including a pattern selector, said pattern selector applying at least one of variable gain and attenuation to outputs of said first and second pattern generating circuitry as a function of an acoustical input to said assembly.

59. A plurality of microphone assemblies according to claim 58 acoustically coupled to a common volume of space.

60. The microphone assembly according to claim 39 further comprising an additional output, said additional output comprised solely of any one of said first, second, and third microphone signals.

61. The microphone assembly according to claim 47 further comprising an additional output, said additional output comprised solely of any one of said first, second, and third electrical microphone signals and exhibiting substantial response at frequencies substantially lower than said first frequency.

62. The microphone assembly according to claim 60 wherein said first and second pattern signals are developed relative to a ground, and said additional output is developed relative to a local ground, said local ground connected to said ground by a ground resistance, said ground resistance exhibiting a resistance of greater than 1/50 of an expected load resistance, and wherein said additional output is developed with an output impedance, said output impedance having a value of greater than 5 times said expected load resistance.

63. The microphone assembly according to claim 61 wherein said first and second pattern signals are developed relative to a ground, and said additional output is developed relative to a local ground, said local ground connected to said ground by a ground resistance, said ground resistance exhibiting a resistance of greater than 1/50 of an expected

load resistance, and wherein said additional output is developed with an output impedance, said output impedance having a value of greater than 5 times said expected load resistance.

64. A microphone assembly comprising:

at least two microphones, each of said at least two microphones receiving sound energy and generating electrical signals corresponding to the sound energy received;

signal processing circuitry, said signal processing circuitry processing the electrical signals into an assembly output signal; and

said at least two microphones and said signal processing circuitry being configured to limit adverse effects on the assembly output signal from amplitude and phase mismatches between the at least two microphones.

65. The microphone assembly according to claim 64 further comprising a case for housing said at least two microphones and said signal processing circuitry.

66. The microphone assembly according to claim 65 wherein the case is mounted on a mounting side of an acoustical barrier.

67. The microphone assembly according to claim 66 wherein the acoustical barrier comprises an interior surface of a passenger vehicle.

68. The microphone assembly according to claim 66 further comprising at least one sealing gasket located between said case and the mounting side of the acoustical barrier.

69. The microphone assembly according to claim 65 further comprising at least two sealing members which seal the at least two microphones to at least two acoustical openings in the case.

70. The microphone assembly according to claim 65 further comprising at least two protective screens located between an inner surface of the case and the at least two microphones.

71. The microphone assembly according to claim 66 further comprising a covering located on at least a portion of a pick-up side of the acoustical barrier.

72. A microphone assembly providing substantial response to an incident sound wave over at least a frequency range from a lower first frequency to an upper second frequency, said assembly comprising:

at least two microphones, each of said at least two microphones generating an electrical microphone signal corresponding to the incident sound wave;

circuitry for generating at least one pattern signal from the electrical microphone signals; and

at least one filter for attenuating frequency components of the at least one pattern signal which are lower than the lower first frequency.

73. The microphone assembly according to claim 72 wherein said at least one filter is a high-pass filter of at least second order.

74. The microphone assembly according to claim 72 wherein the assembly provides substantial response to the incident sound wave over a range of angle of arrival theta, and one of the at least one pattern signal exhibits a pickup pattern which varies according to the angle of arrival theta substantially uniformly over the frequency range, the pickup pattern approximately equal to a microphone directionality modified by a factor of 1-B+B*cos(theta).

75. The microphone assembly according to claim 74 comprising two pattern signals, and wherein one of the two pattern signals exhibits a pickup pattern which varies according to the angle of arrival theta and an offset angle phi substantially uniformly over the frequency range, the pickup pattern approximately equal to a microphone directionality modified by a factor of 1-C+C*cos(theta + phi).

76. The microphone assembly according to claim 72, further comprising an additional ~~output,~~ said additional output solely comprised of any one of the electrical microphone signals.

77. The microphone assembly according to claim 74 wherein two of said at least two microphones are spaced apart by a spacing distance which is not less than 1/5 of a second wavelength, corresponding to the upper second frequency, multiplied by the constant B.

78. The microphone assembly according to claim 75 wherein two of said at least two microphones are spaced apart by a spacing distance which is not less than 1/5 of a second wavelength, corresponding to the upper second frequency, multiplied by the constant C.

79. A microphone assembly providing substantial response to an incident sound wave over at least a frequency range from a lower first frequency to an upper second frequency, said assembly comprising:

at least two microphones, each of said at least two microphones generating an electrical microphone signal corresponding to the incident sound wave; and

said at least two microphones spaced apart by at least one spacing distance and positioned on a microphone side of an acoustical barrier, the barrier of a size having at least one dimension which is greater than a wavelength corresponding to the upper second frequency and providing substantial attenuation of acoustical coupling to the microphone side from an opposite side of the barrier over at least the frequency range, each of said at least two microphones having a diaphragm acoustically coupled through at least one acoustical opening to the opposite side of said barrier, each of the at least one acoustical opening constructed ~~so as to~~ prevent substantial acoustical coupling from the microphone side of said barrier directly to the diaphragm.

80. The microphone assembly according to claim 79 further comprising circuitry for generating at least one pattern signal from the microphone signals and wherein the assembly provides substantial response to the incident sound wave over a range of angle of arrival theta, one of said at least one pattern signal exhibiting a pickup pattern which varies according to the angle theta substantially uniformly over the frequency range, the pickup pattern approximately equal to 1-B+B*cos(theta) within a volume of space acoustically coupled to two of the diaphragms.

81. The microphone assembly according to claim 80 comprising two pattern signals, and wherein one exhibits a pickup pattern which varies according to the angle of arrival theta and an offset angle phi substantially uniformly over the frequency range, the pickup pattern approximately equal to a microphone directionality multiplied by a factor of 1-C+C*cos(theta + phi) within a volume of space acoustically coupled to two of said diaphragms.

82. The microphone assembly according to claim 79 wherein the diaphragms are positioned parallel to the barrier.

83. The microphone assembly according to claim 79 further comprising at least one filter for attenuating frequency components of the at least one pattern signal which are lower than the lower first frequency.

84. A microphone assembly for use in a passenger vehicle comprising:

at least two microphones, each of said at least two microphones having a diaphragm; and

said at least two microphones being spaced apart by at least one spacing distance and positioned on a microphone side of an acoustical barrier, each of the diaphragms being acoustically coupled through at least one acoustical opening for each diaphragm to an opposite side of the barrier, each of said at a least one acoustical opening constructed to limit acoustical coupling from the microphone side of the barrier directly to the diaphragm.

85. The microphone assembly of claim 84 further comprising a case for housing the at least two microphones.

86. A microphone assembly for use in a vehicle comprising:

a case having an opening, an inner surface and an outer surface;

a microphone mounted within the case, said microphone having a diaphragm and an acoustically open end;

said case mounted on an inner surface of an acoustical barrier, said acoustical barrier having an opening and an outer surface;

a case sealing member having an opening, said case sealing member sealing ~~the acoustically~~ open end of the microphone to the opening in said case;

a mounting ~~sealing~~ member having an opening, said mounting sealing member located between the outer surface of the case and the inner surface of the acoustical barrier; and

the openings in the case sealing member, the case, the mounting sealing member and the acoustical barrier providing acoustical coupling of sound energy from a region beyond the outer surface of the acoustical barrier to the diaphragm of the microphone.

87. The microphone assembly according to claim 86 wherein the opening in the case sealing gasket is of greater size than the opening in the case.

88. The microphone assembly according to claim 86 wherein the opening in the mounting sealing gasket is of greater size than the opening in the case and the opening in the acoustical barrier.

89. The microphone assembly according to claim 86 further comprising a protective screen located between the case sealing gasket and the inner surface of the case.

90. The microphone assembly according to claim 86 further comprising a covering on at least a portion of the outer surface of the acoustical barrier.

91. A microphone assembly providing substantial response to an incident sound wave over at least a frequency range from a lower first frequency to an upper second frequency, said assembly comprising:

at least two microphones, each of said at least two microphones generating an electrical microphone signal corresponding to the incident sound wave, each of said at least two microphones exhibiting a substantially flat frequency response over a range of frequencies from a respective lower cutoff frequency to a respective upper cutoff frequency, each of the lower cutoff frequencies being lower than the first frequency and each of the upper cutoff frequencies being higher than the second frequency; and

circuitry for attenuating the microphone signals at frequencies below at least one roll-off corner frequency, and responsively producing at least two rolled-off signals, said at least one roll-off corner frequency lying above each of the respective lower cutoff frequencies of said microphones.

92. The microphone assembly of claim 91 wherein the circuitry comprises at least two roll-off filters.

93. A microphone assembly for mounting behind an interior surface of a vehicle comprising:

two omnidirectional microphone elements, each of said omnidirectional microphone elements being at least substantially acoustically sealed from a mounting side of the surface and acoustically coupled to a pickup side of the surface, said omnidirectional microphone elements together creating a directional pickup pattern on the pickup side of the surface.

ADD A2

ADD B1